## Probability of launching *AFTA, by early 2020's*

$$\mathcal{P} = K \times e^{(\$1.6B - cost)}$$

*Where K = 0.50 (50% chance) due to factors beyond our control (programmatics, budget, etc.)*

$\mathcal{P}$ = 91% at cost = $1.0B

$\mathcal{P}$ = 68%  ………    $1.3B

$\mathcal{P}$ = 50%  ………    $1.6B

$\mathcal{P}$ = 30%  ………    $2.1B

$\mathcal{P}$ = 18%  ………    $2.6B

In my opinion, we need to immediately set ourselves to the task of keeping the 'cost' ≤ $1.6B

'cost' = (telescope) + spacecraft + instrument(s) + I&T + launch + ops

***Targets:***

Telescope mods  ≤ $50M
Instrument(s)  ≤ $250M
Spacecraft  ≤ $300M
Integrate & test  ≤ $500M
Launch  ≤ $300M
Operations  ≤ $200M

Total  ≤ $1600M

Is it possible to get down to closer to $1B?
Yes.  For example
(1) get a free launch,
(2) reduce I&T to $300M
(3) Some other funding source for instruments. e.g. Explorer proposal, Astro planetary science tech development line, another Agency, International partnership…

**Suggested course of action at GSFC meeting**

Okay to compare performance to WFIRST SDT DRM1, but stop setting the science goals for AFTA from the CRM1 design effort!

Set parameters for a <u>minimal mission.</u> For example:

1) "as-is" & 'room temperature' telescope – set by AFTA SDT charge

2) Imaging scale = 0.09 arcsec pix$^{-1}$ Imaging field and spectroscopy field
   = 0.25 ± 0.07 deg² (100 x HST WFC3, 3x ph, 2x psf DRM1)

3) <u>Imaging</u>: 1.0μm < λ < 2.0μm    <u>Spectroscopy</u> : 1.3μm < λ < 2.0μm (one pass!)
    y,z,J,H,K⁻                           BAO – Hα:        1.0 < z < 2.0
                                         Gal Evol – [O III], Hβ: 1.3 < z < 3.0

4) Modular spacecraft for servicing option, if it doesn't blow up the cost

5) Modular instrument(s) for servicing option, compared to higher level of redundancy and no upgrade of instruments on orbit

6) Lowest cost orbit and operations

# Difficulty & more FOV

Go rectangle!

- ## Baseline 6x3
  - Judgment is that 4 or more rows of active H4RGs does not fit unvignettable field
  - Note that colors are for imaging mode
    - Focal prisms may not work in portions yellow region
      - Preliminary look says 2 grisms, each covering half of 1.3-2.4um bandpass, is an alternative
    - Focal prisms much more difficult with curved layout

1.3 – 2.0µm!

| "/p &#124; layout | 6x3 | 8x3 | 10x3 |
|---|---|---|---|
| 0.09 | 0.188 | 0.251 | 0.313 |
| 0.1 | 0.232 | 0.309 | 0.387 |
| 0.11 | **0.281** | 0.374 | 0.468 |
| 0.12 | 0.334 | 0.446 | 0.557 |
| 0.13 | 0.392 | 0.523 | 0.654 |
| 0.14 | 0.455 | 0.607 | 0.758 |

Layout table:
X – layout (H4RG (10um))
Y – pixel scale, arcsec
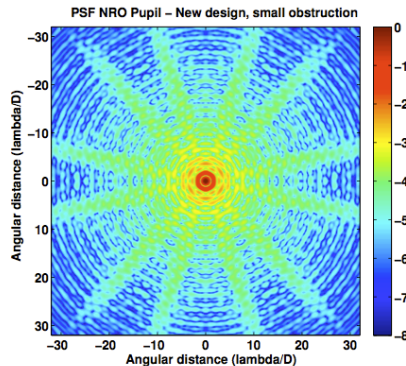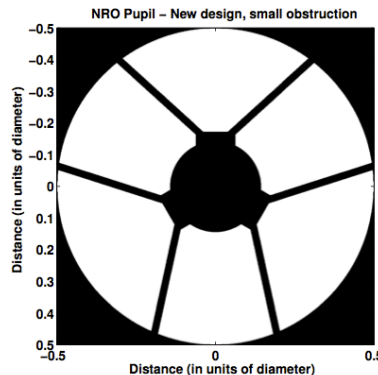Data: FOV area, sq. deg.
Colors are **qualitative guess**, as to doable, hard, very hard, unworkable; for green/yellow/red/black respectively
Baseline is 0.11 6x3

## Two AFTA Pupil Configurations



NRO Pupil – New design, small obstruction



PSF NRO Pupil – New design, small obstruction

Whole pupil Is really bad for coronography, but subapertures will be unobstructed (off-axis) mirrors like future missions. More stable because it is unobstructed!

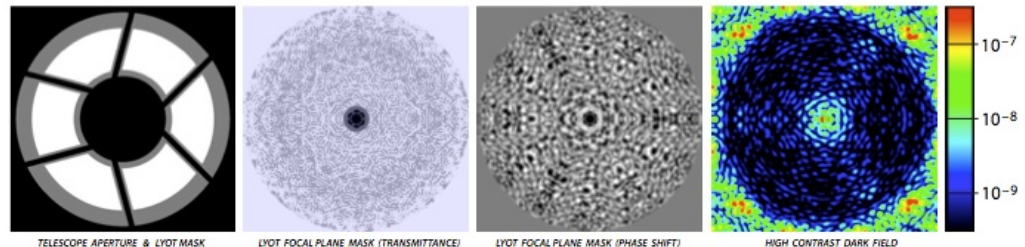0.7-m sub-apertures →
$\lambda/D$ = 0.30 arcsec at $\lambda$ = 1.0μm

Detect Earth twin around Alpha Cen at 1 AU = 3.3 $\lambda/D$ ? ($6 \times 10^{-10}$)

Detect Jupiter twin around 8 pc star at 5 AU at 2 $\lambda/D$ ? ($3 \times 10^{-9}$)

Detect 2 x zodi disk around 8 pc star at 2 AU at 1 $\lambda/D$ ($10^{-8}$)
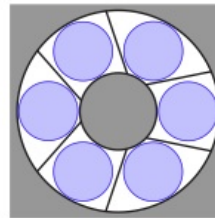


Case 2: complex apodization Lyot coronagraph for the full AFTA aperture – early analysis –

TELESCOPE APERTURE & LYOT MASK    LYOT FOCAL PLANE MASK (TRANSMITTANCE)    LYOT FOCAL PLANE MASK (PHASE SHIFT)    HIGH CONTRAST DARK FIELD

- As in foregoing Lyot coronagraph designs, the focal plane mask controls both real and imaginary parts of the complex wavefront, using one metal and one dielectric layer on a glass substrate.
- We begin our design optimization with an idealized solution assuming perfect optics, no wavefront corrections, and monochromatic light.
- In the example shown above, raw contrast averages 6e-10 from 2.5 to 24 lambda/D.
- Next step, now in progress, is to introduce deformable mirror(s) and further adjustments of the focal plane mask to extend spectral bandwidth from a few% to as broad as 20% while maintaining high contrast.